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APOLLO-USBS FLYBY TESTS
A PRELIMINARY QUICK LOOK NOISE ANALYSIS

BY

W.D. KAHN

SEPTEMBER 1966

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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ABSTRACT

A preliminary analysis of Unified S-Band System high speed range rate and X-Y angular data obtained during the aircraft flyby tests at Bermuda (March 15, 1966), Carnarvon (March 25, 1966), and Merritt Island (April 19, 1966), will be discussed. In brief, this analysis consisted of fitting polynomials (up to fifth degree) in the least squares sense to tracking data over numerous short data acquisition intervals (to minimize effects due to the motion of the aircraft). The resulting standard deviations of fit are used as measures of the noise characteristics associated with each data type analyzed.

CONCLUSIONS

From this preliminary analysis the following conclusions can be drawn.

(a) The average noise for the Bermuda system angular components (X-Y) is in the order of 0.05 milliradians as is shown in Figures 2 and 3 and is approximately 0.1 milliradians for the Carnarvon system.

(b) The angular noise errors obtained from data anlysis are lower than the specifications call for (i.e., our specifications call for an angular noise error no greater than 0.15* milliradians). The results obtained therefore indicate a well build antenna and servo system.

(c) No conclusions should be drawn from the range rate evaluation since the aircraft's motion (noise) may completely mask the real errors in range rate.

(d) No high speed range data where available for analysis.

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*GSFC-TDS-RFS-220; "Performance Specifications on acquisition Tracking Receiver;" July 8, 1964, page 8, paragraph 3.3.3.10.

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INTRODUCTION

Acceptance tests for the 30-foot Unified S-Band Tracking Systems were begun during the early part of March 1966. These tests, also referred to as "flyby tests," provided the Mission Analysis Office with the first USB-System range rate and X-Y angular data for evaluation.

High speed (10 measurements/second) range rate (using destructive N count) and X-Y angular data were obtained from the March 15, 1966, flyby tests at Bermuda and the March 25, 1966, flyby test at Carnarvon. Only X-Y angular data were available for analysis from the April 19, 1966, flyby test at Merritt Island. For the flyby tests, the Unified S-Band System tracked a C-54 aircraft carrying the USBS transponder. This aircraft flew at an average altitude of 10,000 ft (~3.0 km) and with an average speed of 156 n.mi./hr. (~80 meters/sec.).

The evaluation of the flyby test data consisted of fitting (in the least squares sense) polynomials up to degree 5 to the tracking data. In order to minimize effects due to the aircraft's motion, short tracking data intervals ranging from 5 seconds to 50 seconds were used. The restriction of fitting only up to 5th degree polynomials is due to a limitation in the computer program used for the data analysis. This program, in order to determine the degree polynomial which best fits the data, uses as a criterion the ratio of the variance of fit from two successive degree polynomial fits to the same data. If the ratio of the higher degree polynomial's variance to the lower degree polynomial's variance is greater than or equal to 0.9 but less than or equal to 1.0, then the lower degree polynomial is accepted as the best fit to the data. If the ratio is less than 0.9, the fitting of higher degree polynomials to the data continues up to degree 5. If, at this point, the ratio is still less than 0.9, the 5th degree polynomial is accepted as the best fit to the data. The standard deviation (square root of the variance) of the residuals to these polynomials then is a measure of the noise characteristic of the tracking data.

Points on each of the graphs of figures 1-4 and 14-19 (except 16b) represent the "standard deviations of fit" resulting from the fitting of polynomials to the same tracking data type over different data intervals. The data intervals were each arbitrarily assigned numbers in chronological order except in figure 15a and 15b and were used as the abscissa values on the graphs. The degree of the polynomial fitted to the data, starting and ending times for the data interval, and the number of data points are listed by "data interval number" on the table accompanying each graph.

DISCUSSION OF RESULTS

Figures 1 through 3 show the noise characteristics of range rate and X-Y angular data obtained from the March 15, 1966, flyby test at Bermuda. The noise in the range rate data for the tracking intervals sampled was found never to exceed ± 4 cm/sec. Likewise, the noise in the X-Y angular data never exceeded ± 0.2 milliradians. All data analyzed from the Bermuda flyby test were over 10 second tracking intervals (mostly consecutive).

Figures 4 through 16 show the results of the tracking data analysis from the March 25, 1966, flyby test at Carnarvon. During this test, the noise characteristic of the range rate data was found to be approximately ± 10 cm/sec when the data interval is 10 seconds (see data intervals 1-9 in figure 4). However, if the data interval is expanded from 10 seconds to 20 seconds, there is considerable degradation in the noise characteristic (see data intervals 9-12).

Figures 5 through 9 are frequency histograms of the range rate residuals for five different data intervals. It is seen that the distributions are non-Gaussian.

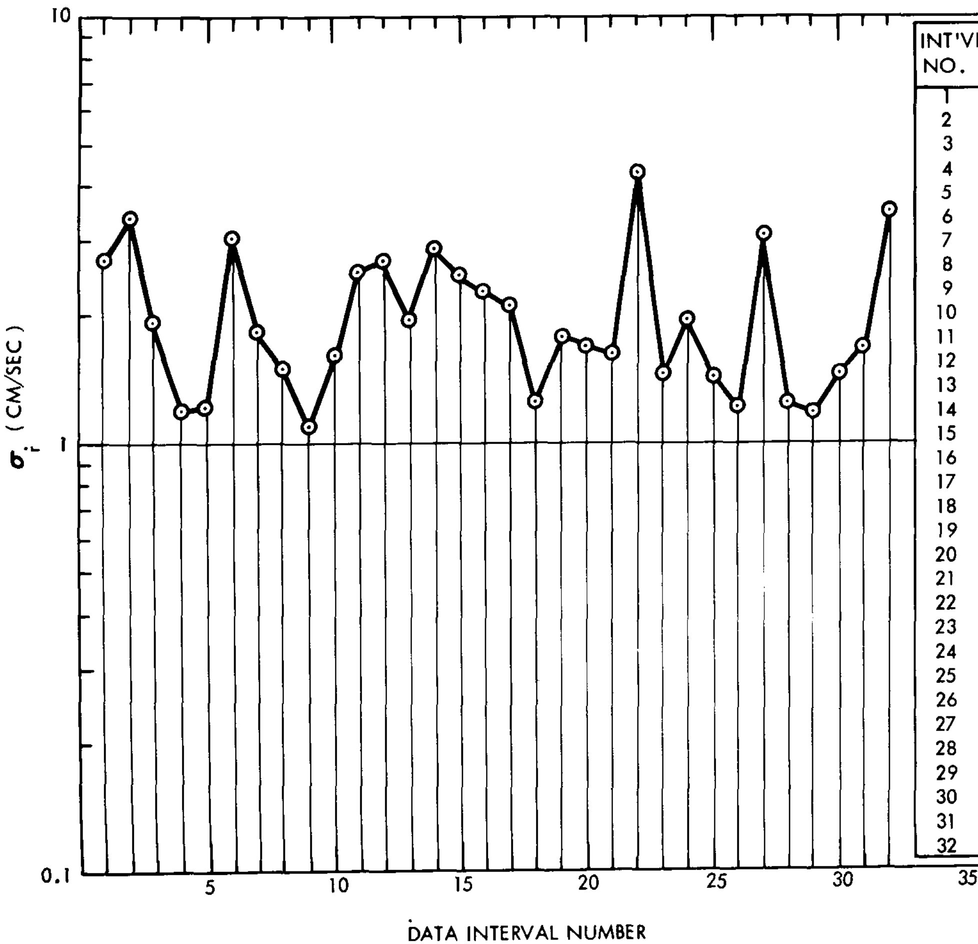
Figures 10 through 13 are plots of the autocorrelation function for the same data intervals for which the frequency histograms have been constructed. Results from the autocorrelation analysis are inconclusive. The plots of the autocorrelation function were included here only for the sake of demonstrating the techniques used for flyby test data analysis. Normally autocorrelation analysis is used as a tool for searching for the existence of periodicities in data, which did not exist in this case.

Figures 15a and 15b give the noise characteristics for X-angle data when using an expanded tracking data interval. Considering data used in figure 15a, the noise increases from ± 0.09 milliradians (over a 5-second data interval) to approximately ± 0.2 milliradians (over a 40-second data interval). Analysis of X-angle data obtained approximately 1 minute later (see figure 15b) shows a variation in the noise from ± 0.25 milliradians (over a 5-second data arc) to ± 0.9 milliradians (over a 50-second data interval). The increase in the noise can be correlated with the expanding data interval.

Figure 16 gives the analysis of Y-angle data over 6 consecutive 5-second data intervals, 3 consecutive 15-second intervals, and one 25-second interval.

A rapid increase in noise is noted by comparing the polynomial fits over 5-second data intervals with those over 15-second data intervals. The maximum noise characteristic in Y-angle data (± 0.23 milliradians) was that resulting from a polynomial fit over a 15-second data interval. A frequency historgram of Y-angle residuals (from a polynomial fit over a 25-second data interval) resembles the Gaussian distribution. Thus the noise for this particular data interval may be Gaussian.

As stated previously, only angular data were available for analysis from the Merritt Island flyby test. Figures 17 through 19 show the data noise to be consistently less than ± 0.2 milliradians. The results from the analysis of Merritt Island flyby test data should be better than that obtained from the Bermuda and Carnarvon flyby tests since with two exceptions only (see figures 17 and 19) 5-second data intervals were analyzed. Merritt Island data available from the April 19, 1966, flyby test was limited to a few short data intervals, of which those in figures 17-19 are representative. Much of the data available for analysis was classified for one reason or another as invalid.



INT'VL NO.	DATE 1966	INITIAL TIME HR-MIN-SEC	FINAL TIME HR-MIN-SEC	NO.OF POINTS	DEGREE OF POLYNOMIAL
1	3/15	1 -15 -56.6	1 -16 -06.5	100	4
2	3/15	1 -16 -06.6	1 -16 -16.5	100	5
3	3/15	1 -16 -16.6	1 -16 -26.5	100	4
4	3/15	1 -16 -26.6	1 -16 -36.5	100	5
5	3/15	1 -16 -36.6	1 -16 -46.5	100	5
6	3/15	1 -16 -46.6	1 -16 -56.5	100	5
7	3/15	1 -16 -56.6	1 -17 -06.5	100	5
8	3/15	1 -17 -06.6	1 -17 -16.5	100	3
9	3/15	1 -17 -16.6	1 -17 -26.5	100	5
10	3/15	1 -17 -26.6	1 -17 -36.5	100	5
11	3/15	1 -17 -36.6	1 -17 -46.5	100	5
12	3/15	1 -17 -46.6	1 -17 -56.5	100	5
13	3/15	1 -17 -56.6	1 -18 -06.5	100	5
14	3/15	1 -18 -06.6	1 -18 -16.5	100	5
15	3/15	1 -18 -16.6	1 -18 -26.5	100	3
16	3/15	1 -18 -26.6	1 -18 -36.5	100	5
17	3/15	1 -18 -36.6	1 -18 -46.5	100	5
18	3/15	1 -18 -46.6	1 -18 -56.5	100	5
19	3/15	1 -18 -56.6	1 -19 -06.5	100	4
20	3/15	1 -19 -06.6	1 -19 -16.5	100	5
21	3/15	1 -19 -16.6	1 -19 -26.5	100	5
22	3/15	1 -19 -26.6	1 -19 -36.5	100	5
23	3/15	1 -19 -36.6	1 -19 -46.5	100	4
24	3/15	1 -19 -46.6	1 -19 -56.5	100	3
25	3/15	1 -19 -56.6	1 -20 -06.5	100	5
26	3/15	1 -20 -06.6	1 -20 -16.5	100	5
27	3/15	1 -20 -16.6	1 -20 -26.5	100	3
28	3/15	1 -20 -26.6	1 -20 -36.5	100	5
29	3/15	1 -20 -36.6	1 -20 -46.5	100	5
30	3/15	1 -29 -24.6	1 -29 -34.5	100	5
31	3/15	1 -29 -34.6	1 -29 -44.5	100	5
32	3/15	1 -29 -44.6	1 -29 -54.5	100	5

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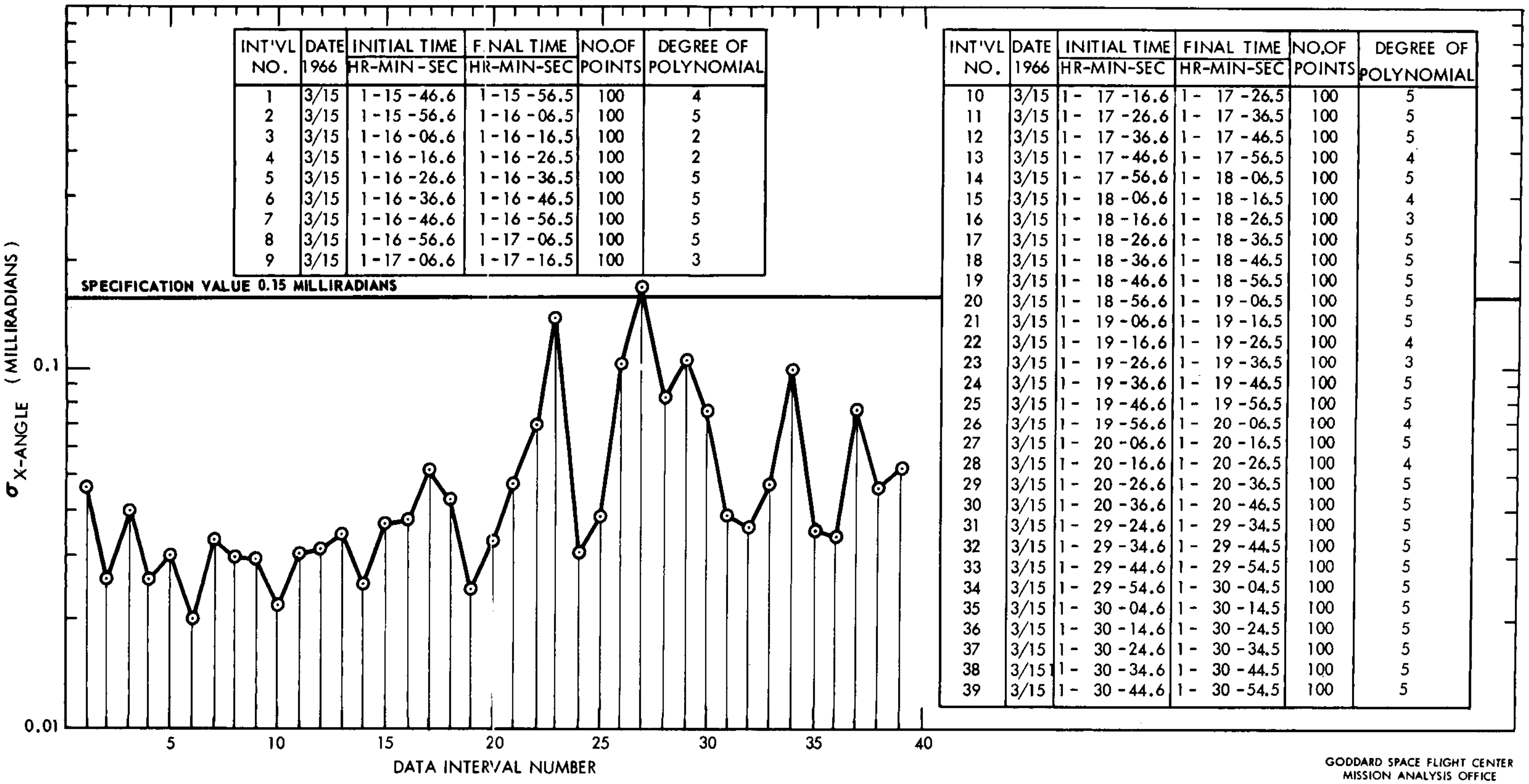
Bermuda Flyby - March 15, 1966 Range Rate Data

Figure 1

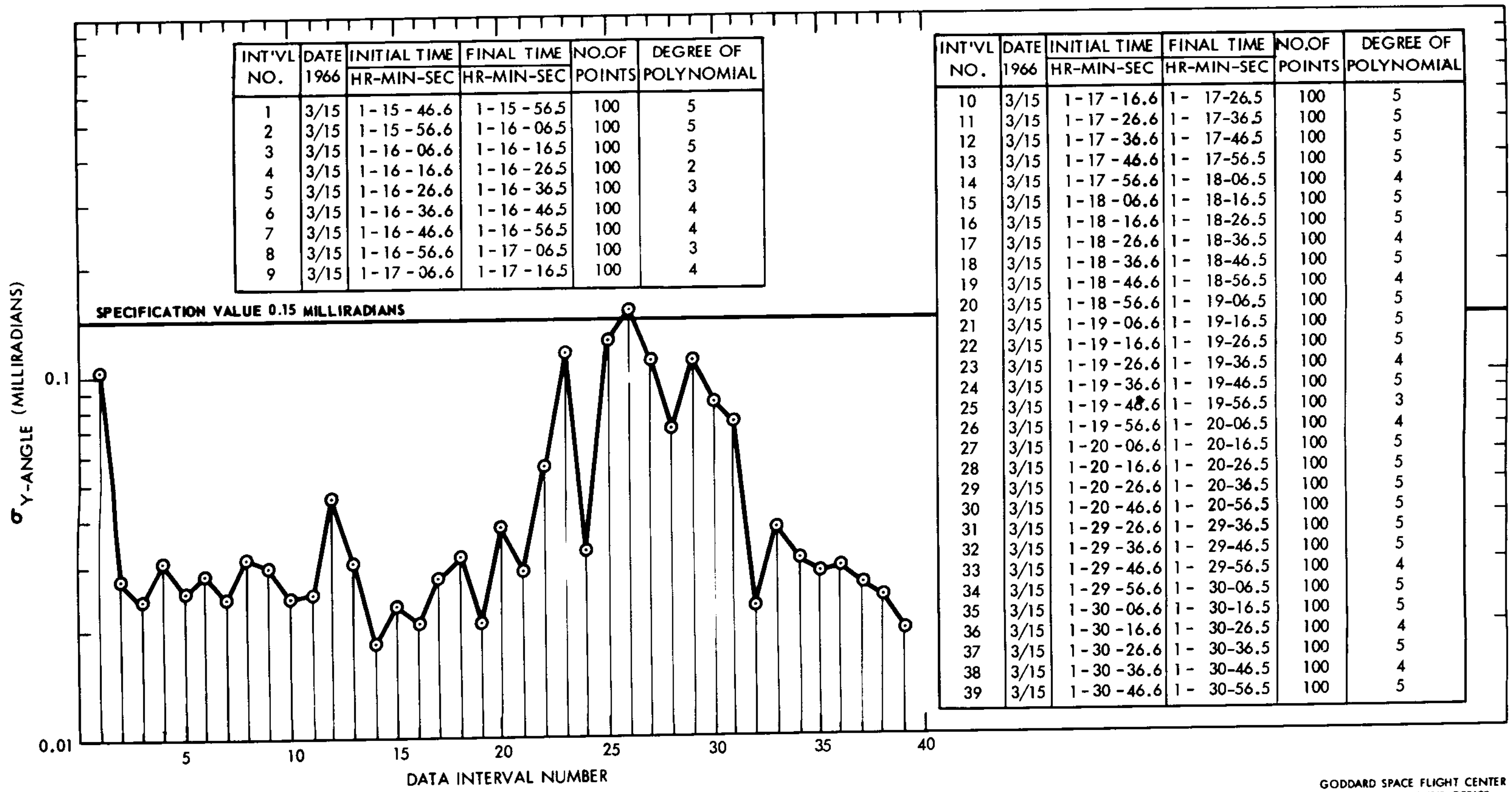


INT'VL NO.	DATE 1966	INITIAL TIME HR-MIN-SEC	FINAL TIME HR-MIN-SEC	NO.OF POINTS	DEGREE OF POLYNOMIAL
1	3/15	1-15-46.6	1-15-56.5	100	4
2	3/15	1-15-56.6	1-16-06.5	100	5
3	3/15	1-16-06.6	1-16-16.5	100	2
4	3/15	1-16-16.6	1-16-26.5	100	2
5	3/15	1-16-26.6	1-16-36.5	100	5
6	3/15	1-16-36.6	1-16-46.5	100	5
7	3/15	1-16-46.6	1-16-56.5	100	5
8	3/15	1-16-56.6	1-17-06.5	100	5
9	3/15	1-17-06.6	1-17-16.5	100	3

INT'VL NO.	DATE 1966	INITIAL TIME HR-MIN-SEC	FINAL TIME HR-MIN-SEC	NO.OF POINTS	DEGREE OF POLYNOMIAL
10	3/15	1- 17-16.6	1- 17-26.5	100	5
11	3/15	1- 17-26.6	1- 17-36.5	100	5
12	3/15	1- 17-36.6	1- 17-46.5	100	5
13	3/15	1- 17-46.6	1- 17-56.5	100	4
14	3/15	1- 17-56.6	1- 18-06.5	100	5
15	3/15	1- 18-06.6	1- 18-16.5	100	4
16	3/15	1- 18-16.6	1- 18-26.5	100	3
17	3/15	1- 18-26.6	1- 18-36.5	100	5
18	3/15	1- 18-36.6	1- 18-46.5	100	5
19	3/15	1- 18-46.6	1- 18-56.5	100	5
20	3/15	1- 18-56.6	1- 19-06.5	100	5
21	3/15	1- 19-06.6	1- 19-16.5	100	5
22	3/15	1- 19-16.6	1- 19-26.5	100	4
23	3/15	1- 19-26.6	1- 19-36.5	100	3
24	3/15	1- 19-36.6	1- 19-46.5	100	5
25	3/15	1- 19-46.6	1- 19-56.5	100	5
26	3/15	1- 19-56.6	1- 20-06.5	100	4
27	3/15	1- 20-06.6	1- 20-16.5	100	5
28	3/15	1- 20-16.6	1- 20-26.5	100	4
29	3/15	1- 20-26.6	1- 20-36.5	100	5
30	3/15	1- 20-36.6	1- 20-46.5	100	5
31	3/15	1- 29-24.6	1- 29-34.5	100	5
32	3/15	1- 29-34.6	1- 29-44.5	100	5
33	3/15	1- 29-44.6	1- 29-54.5	100	5
34	3/15	1- 29-54.6	1- 30-04.5	100	5
35	3/15	1- 30-04.6	1- 30-14.5	100	5
36	3/15	1- 30-14.6	1- 30-24.5	100	5
37	3/15	1- 30-24.6	1- 30-34.5	100	5
38	3/15	1- 30-34.6	1- 30-44.5	100	5
39	3/15	1- 30-44.6	1- 30-54.5	100	5

Bermuda Flyby - March 15, 1966 X - Angle Data

Figure 2



INT'VL NO.	DATE 1966	INITIAL TIME HR-MIN-SEC	FINAL TIME HR-MIN-SEC	NO. OF POINTS	DEGREE OF POLYNOMIAL
1	3/15	1-15-46.6	1-15-56.5	100	5
2	3/15	1-15-56.6	1-16-06.5	100	5
3	3/15	1-16-06.6	1-16-16.5	100	5
4	3/15	1-16-16.6	1-16-26.5	100	2
5	3/15	1-16-26.6	1-16-36.5	100	3
6	3/15	1-16-36.6	1-16-46.5	100	4
7	3/15	1-16-46.6	1-16-56.5	100	4
8	3/15	1-16-56.6	1-17-06.5	100	3
9	3/15	1-17-06.6	1-17-16.5	100	4

INT'VL NO.	DATE 1966	INITIAL TIME HR-MIN-SEC	FINAL TIME HR-MIN-SEC	NO. OF POINTS	DEGREE OF POLYNOMIAL
10	3/15	1-17-16.6	1- 17-26.5	100	5
11	3/15	1-17-26.6	1- 17-36.5	100	5
12	3/15	1-17-36.6	1- 17-46.5	100	5
13	3/15	1-17-46.6	1- 17-56.5	100	5
14	3/15	1-17-56.6	1- 18-06.5	100	4
15	3/15	1-18-06.6	1- 18-16.5	100	5
16	3/15	1-18-16.6	1- 18-26.5	100	5
17	3/15	1-18-26.6	1- 18-36.5	100	4
18	3/15	1-18-36.6	1- 18-46.5	100	5
19	3/15	1-18-46.6	1- 18-56.5	100	4
20	3/15	1-18-56.6	1- 19-06.5	100	5
21	3/15	1-19-06.6	1- 19-16.5	100	5
22	3/15	1-19-16.6	1- 19-26.5	100	5
23	3/15	1-19-26.6	1- 19-36.5	100	4
24	3/15	1-19-36.6	1- 19-46.5	100	5
25	3/15	1-19-46.6	1- 19-56.5	100	3
26	3/15	1-19-56.6	1- 20-06.5	100	4
27	3/15	1-20-06.6	1- 20-16.5	100	5
28	3/15	1-20-16.6	1- 20-26.5	100	5
29	3/15	1-20-26.6	1- 20-36.5	100	5
30	3/15	1-20-46.6	1- 20-56.5	100	5
31	3/15	1-29-26.6	1- 29-36.5	100	5
32	3/15	1-29-36.6	1- 29-46.5	100	5
33	3/15	1-29-46.6	1- 29-56.5	100	4
34	3/15	1-29-56.6	1- 30-06.5	100	5
35	3/15	1-30-06.6	1- 30-16.5	100	5
36	3/15	1-30-16.6	1- 30-26.5	100	4
37	3/15	1-30-26.6	1- 30-36.5	100	5
38	3/15	1-30-36.6	1- 30-46.5	100	4
39	3/15	1-30-46.6	1- 30-56.5	100	5

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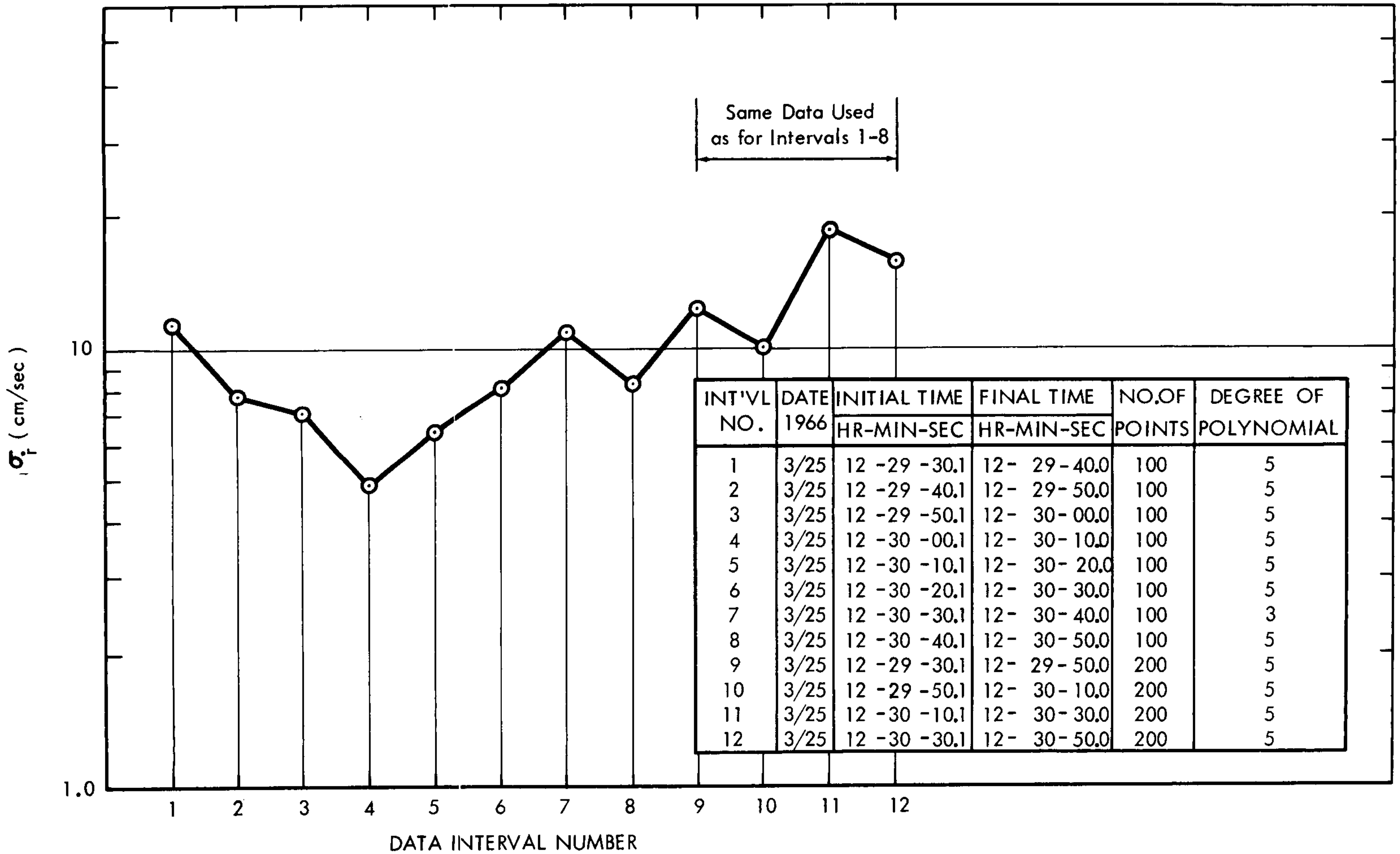
Bermuda Flyby - March 15, 1966 Y - Angle Data

Figure 3



INT'VL NO.	DATE 1966	INITIAL TIME HR-MIN-SEC	FINAL TIME HR-MIN-SEC	NO.OF POINTS	DEGREE OF POLYNOMIAL
1	3/25	12 -29 -30.1	12- 29-40.0	100	5
2	3/25	12 -29 -40.1	12- 29-50.0	100	5
3	3/25	12 -29 -50.1	12- 30-00.0	100	5
4	3/25	12 -30 -00.1	12- 30-10.0	100	5
5	3/25	12 -30 -10.1	12- 30-20.0	100	5
6	3/25	12 -30 -20.1	12- 30-30.0	100	5
7	3/25	12 -30 -30.1	12- 30-40.0	100	3
8	3/25	12 -30 -40.1	12- 30-50.0	100	5
9	3/25	12 -29 -30.1	12- 29-50.0	200	5
10	3/25	12 -29 -50.1	12- 30-10.0	200	5
11	3/25	12 -30 -10.1	12- 30-30.0	200	5
12	3/25	12 -30 -30.1	12- 30-50.0	200	5

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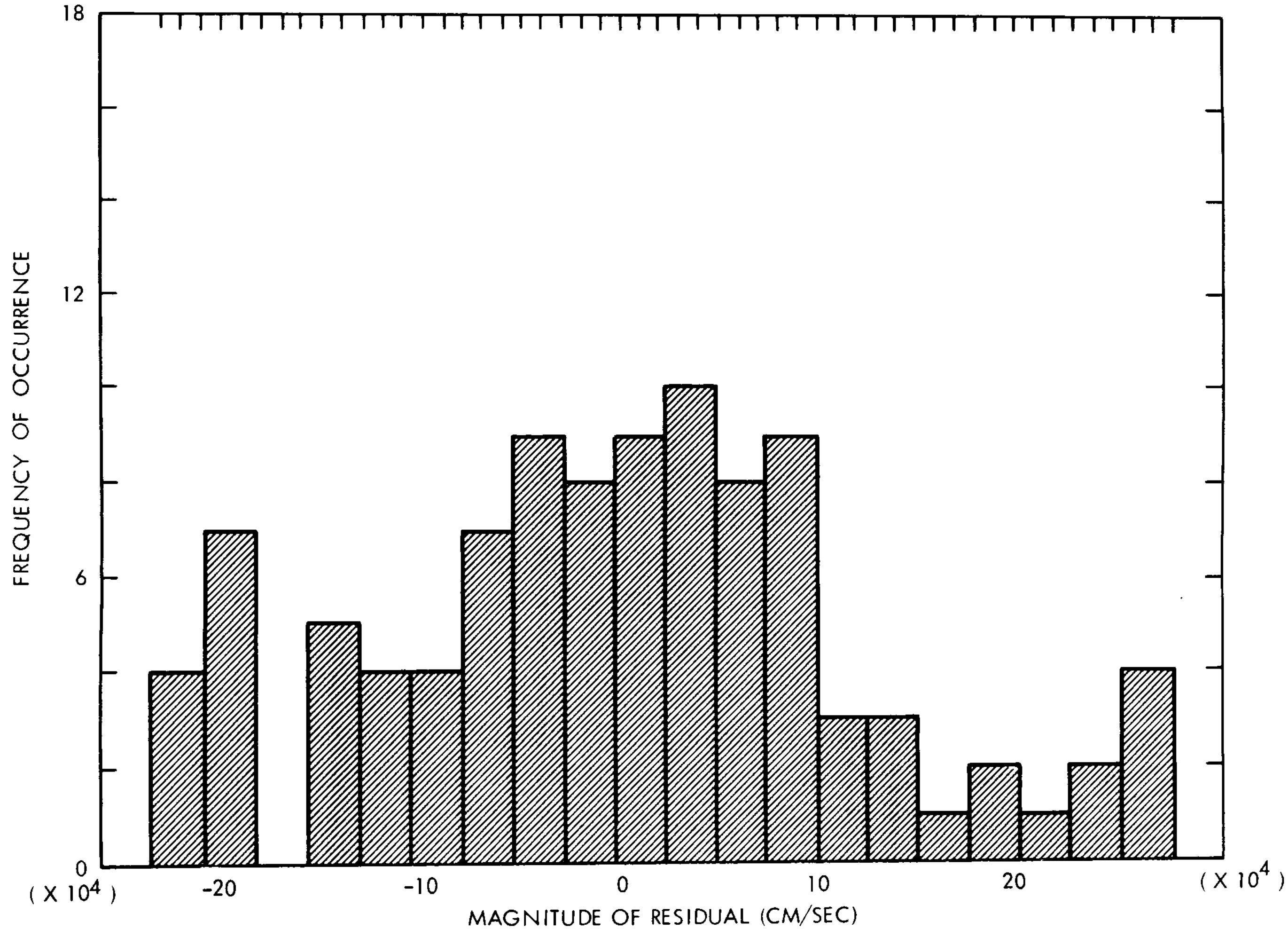
Carnarvon Flyby - March 25, 1966 - Range Rate Data

Figure 4



Carnarvon Flyby - March 25, 1966
Frequency Histogram
Range Rate Data (Interval 1)

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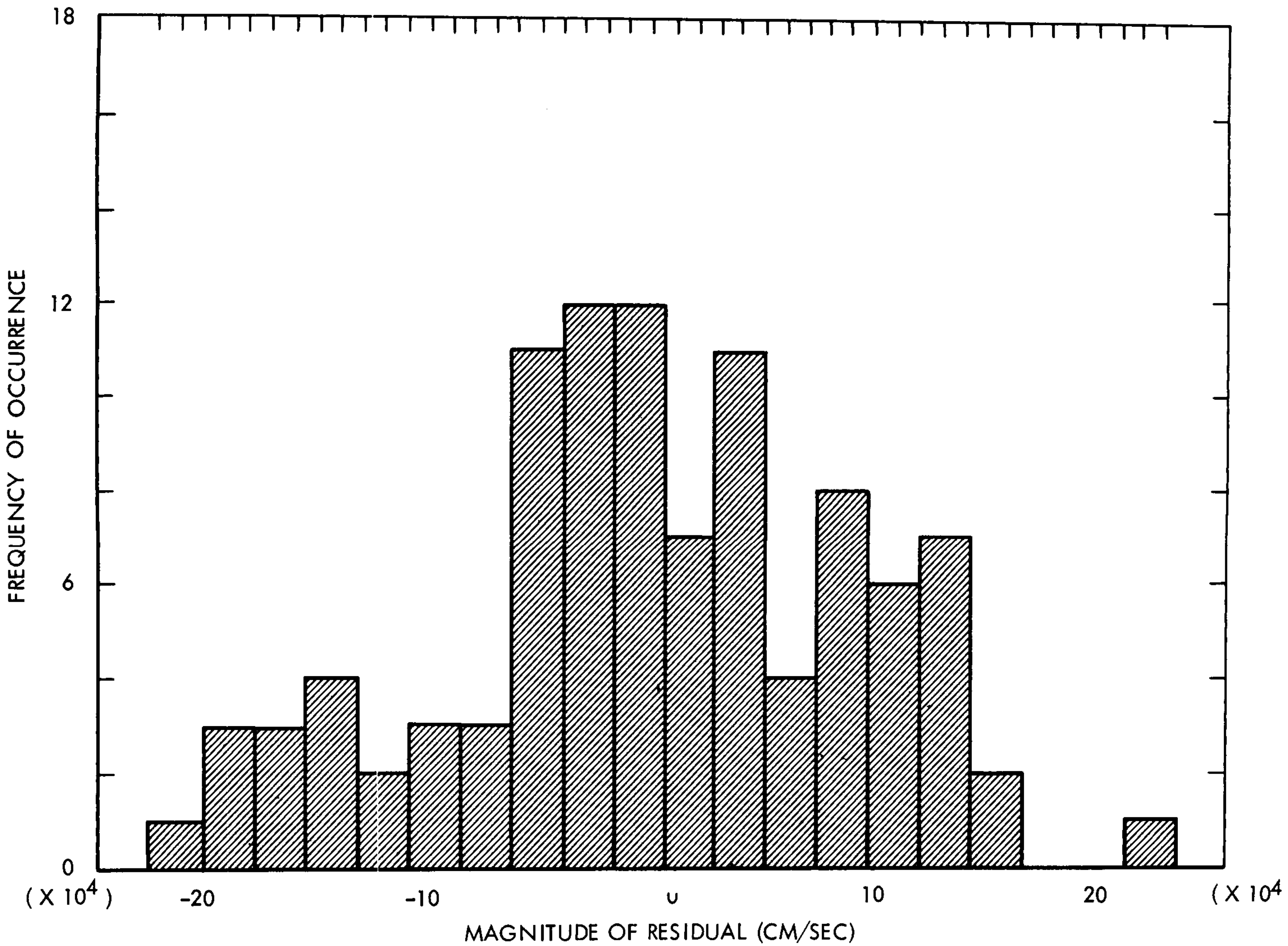
Figure 5



Carnarvon Flyby - March 25, 1966

Frequency Histogram

Range Rate Data (Interval 2)

Figure 6

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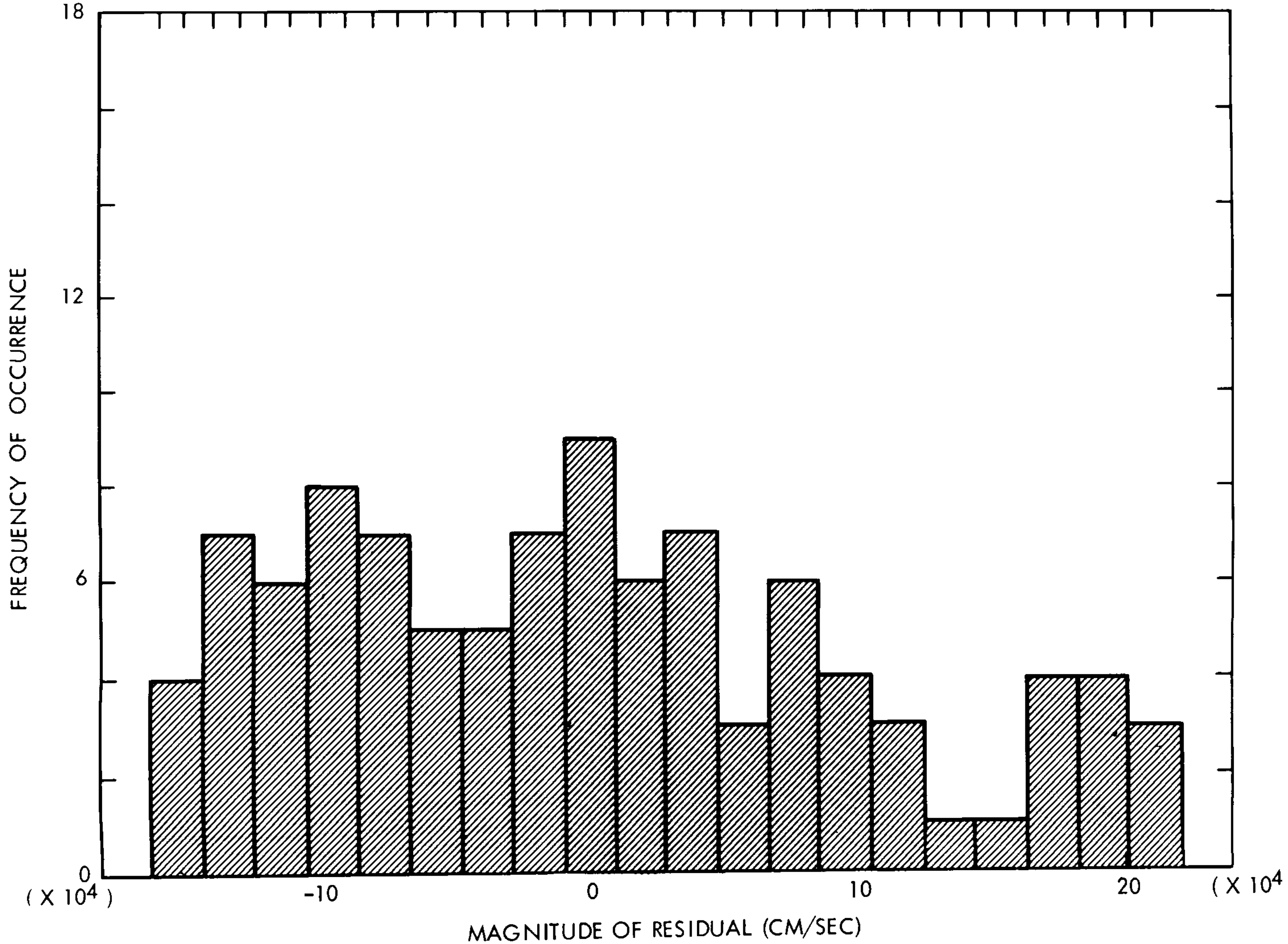

Carnarvon Flyby - March 25, 1966

Frequency Histogram

Range Rate Data (Interval 3)

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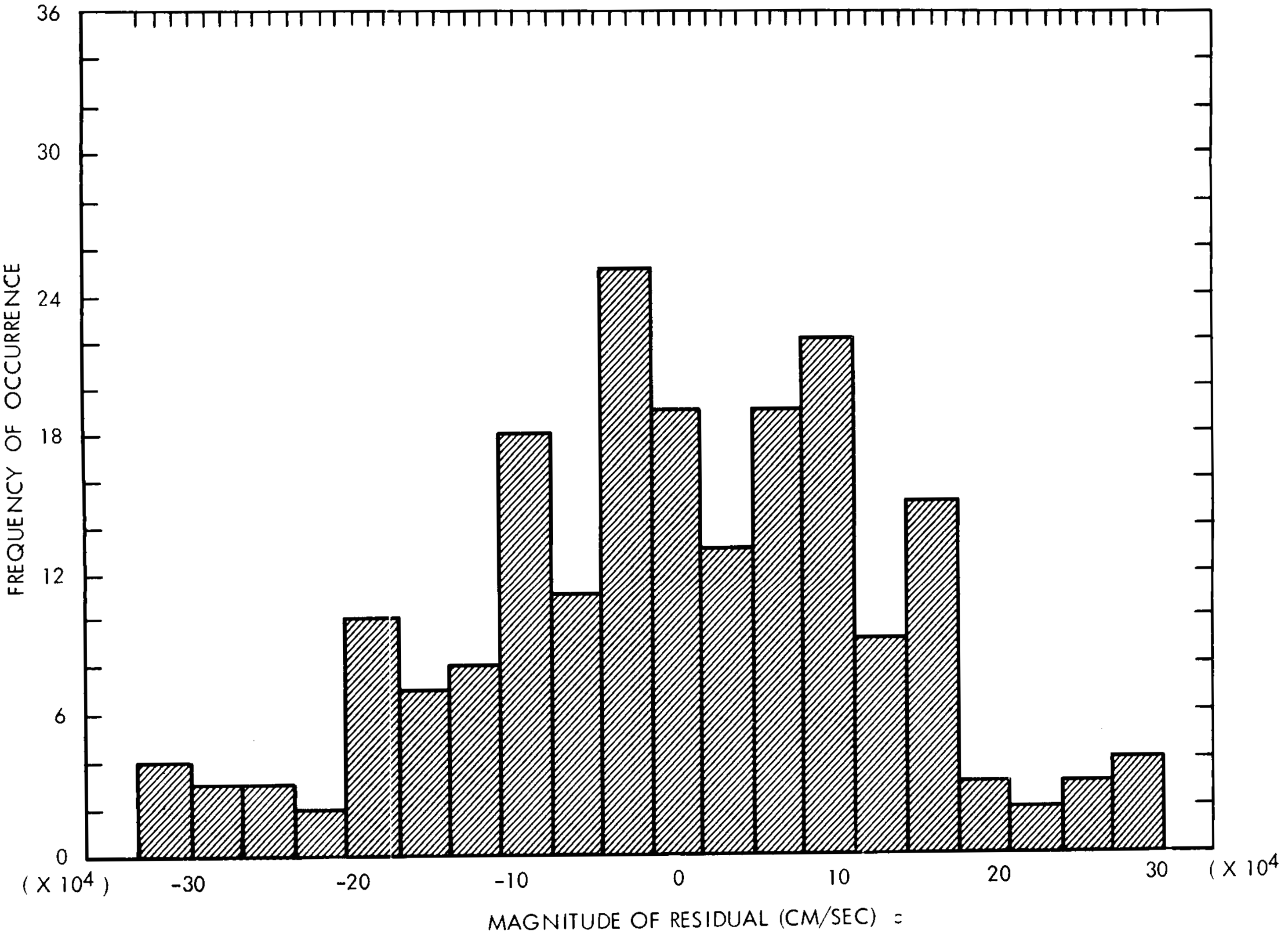
Figure 7



Carnarvon Flyby - March 25, 1966

Frequency Histogram

Range Rate Data (Interval 9)

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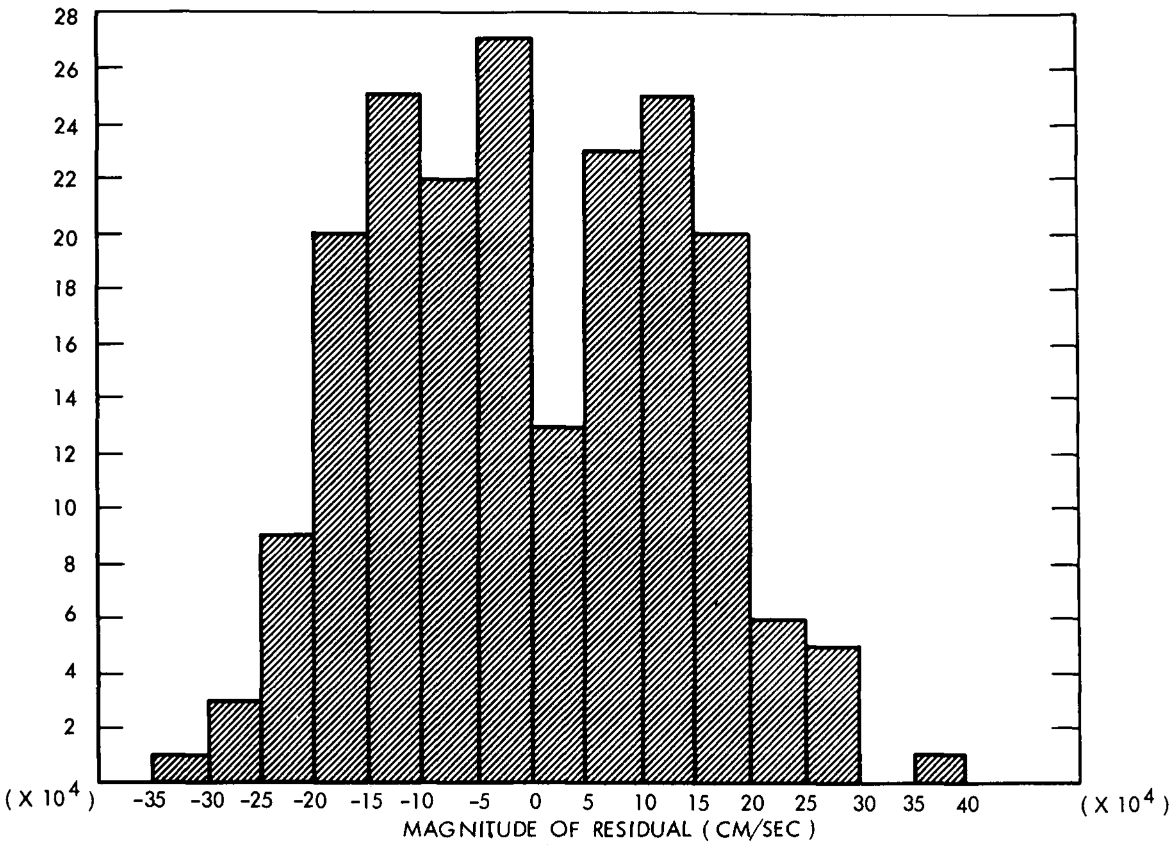
Figure 8



Carnarvon Flyby - March 25, 1966
Frequency Histogram
Range Rate Data (Interval 10)

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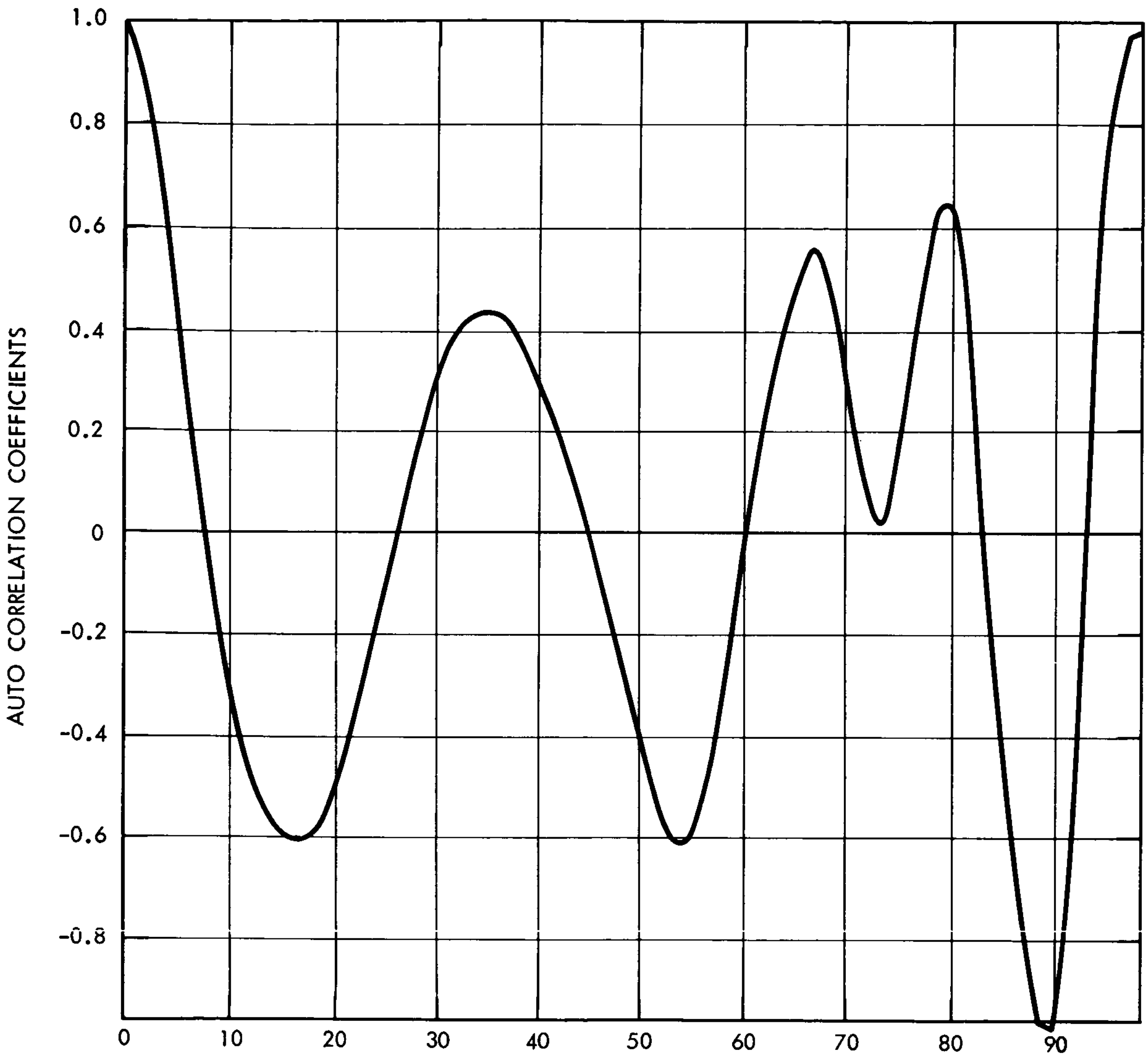
Figure 9



Carnarvon Flyby - March 25, 1966
Auto Correlation Function For
Range Rate Data (Interval 1)

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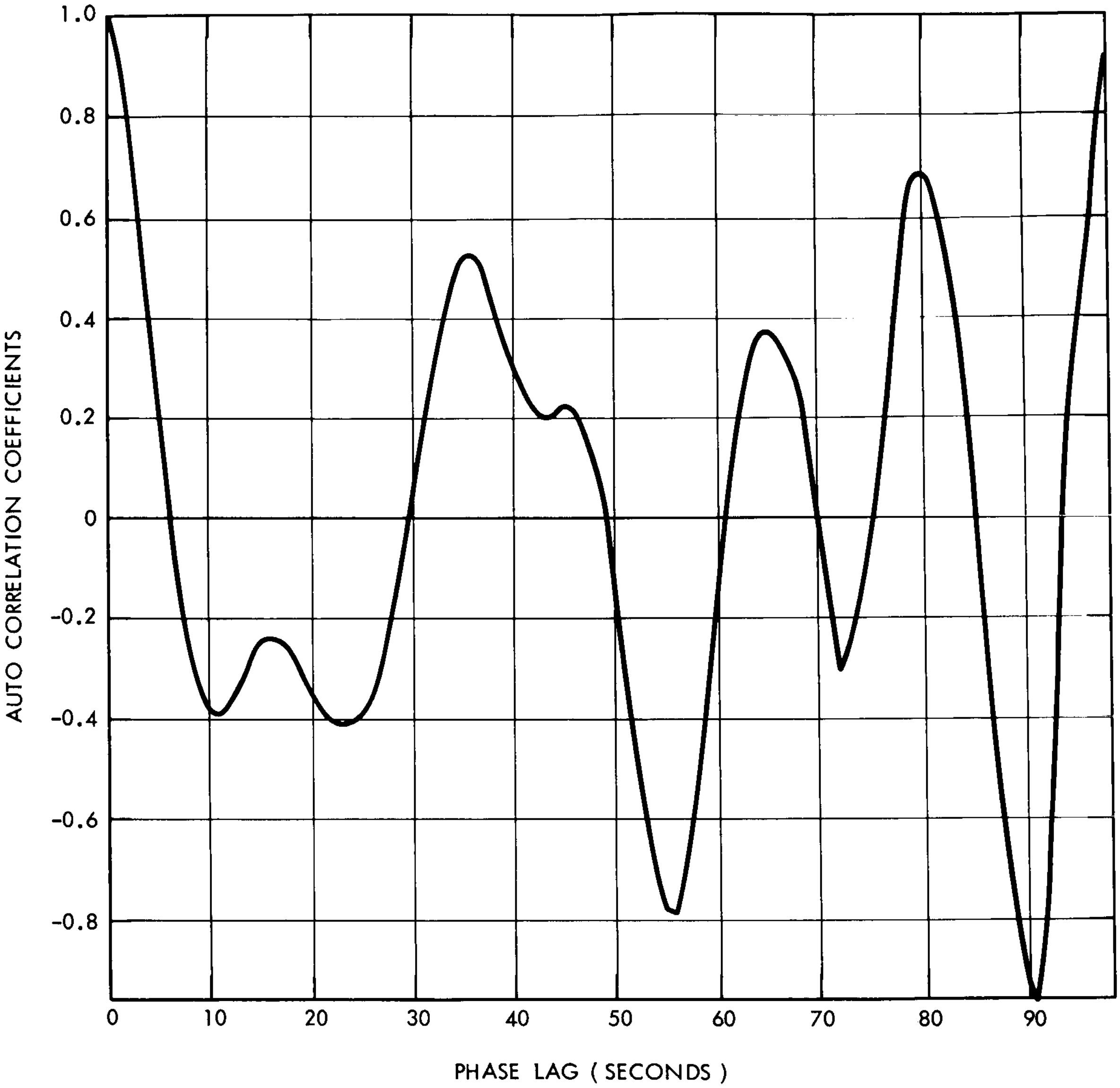
Figure 10



Carnarvon Flyby - March 25, 1966
Auto Correlation Function For
Range Rate Data (Interval 2)

Figure 11

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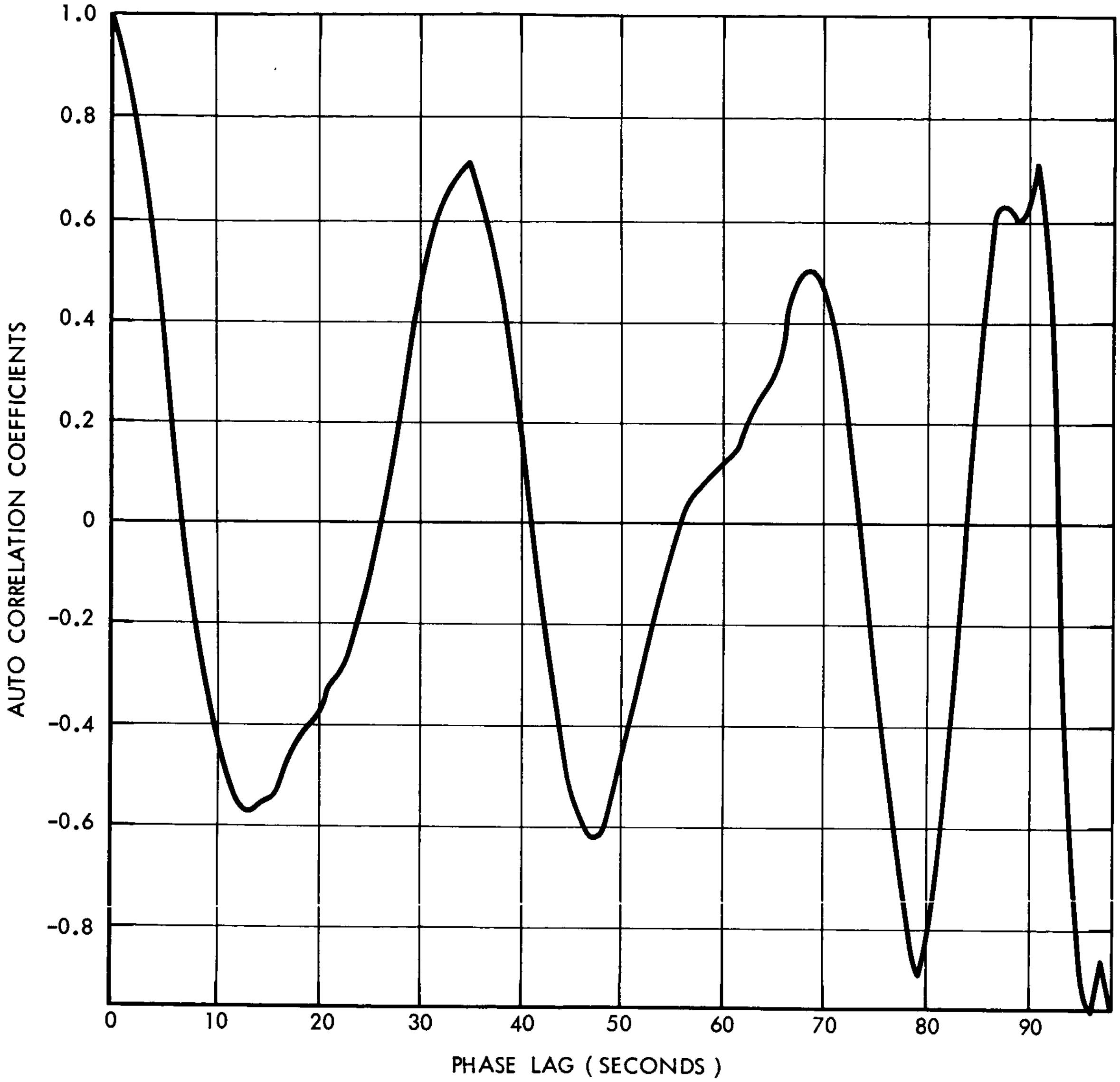

Carnarvon Flyby - March 25, 1966
Auto Correlation Function For
Range Rate Data (Interval 3)

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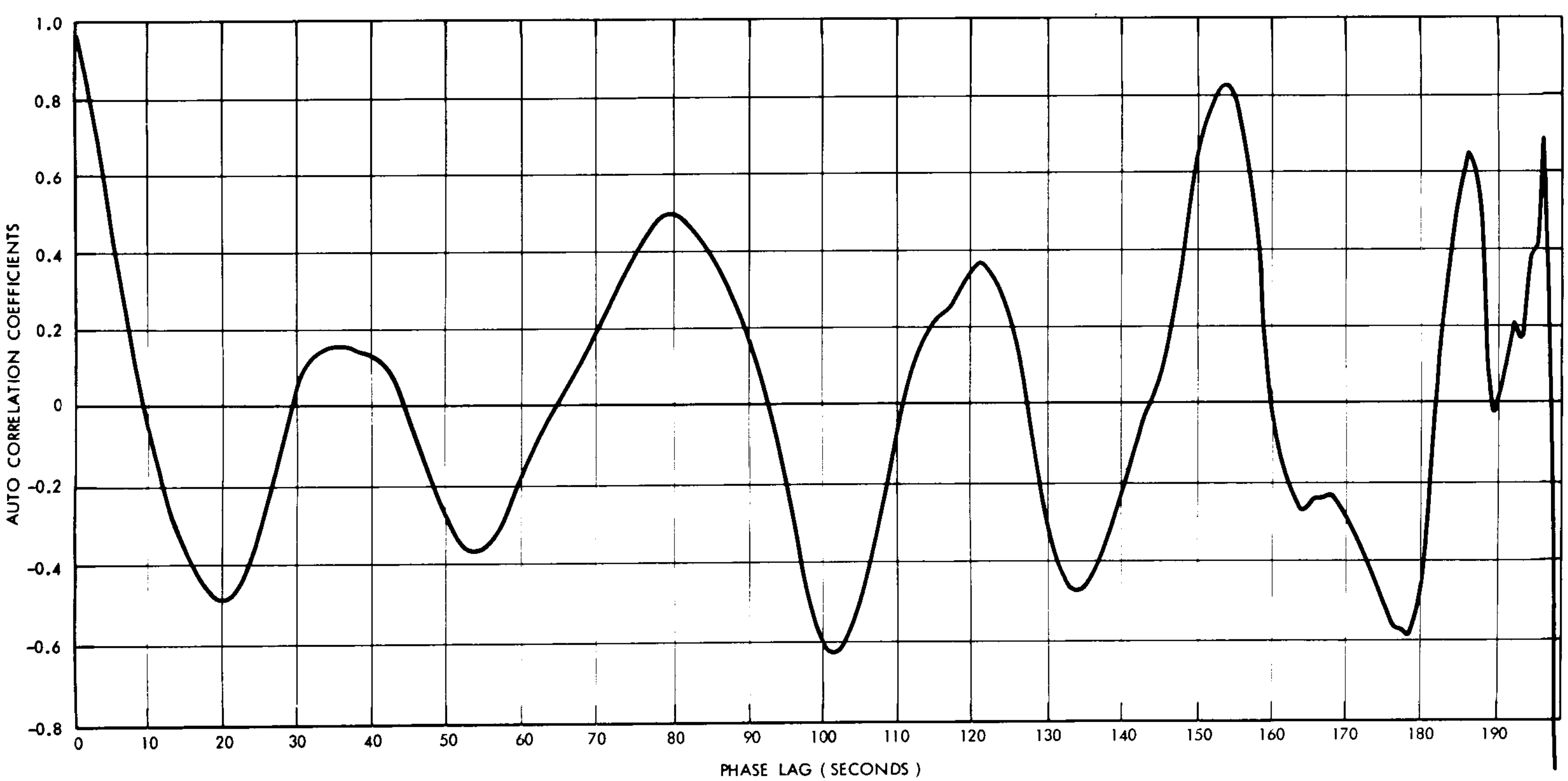
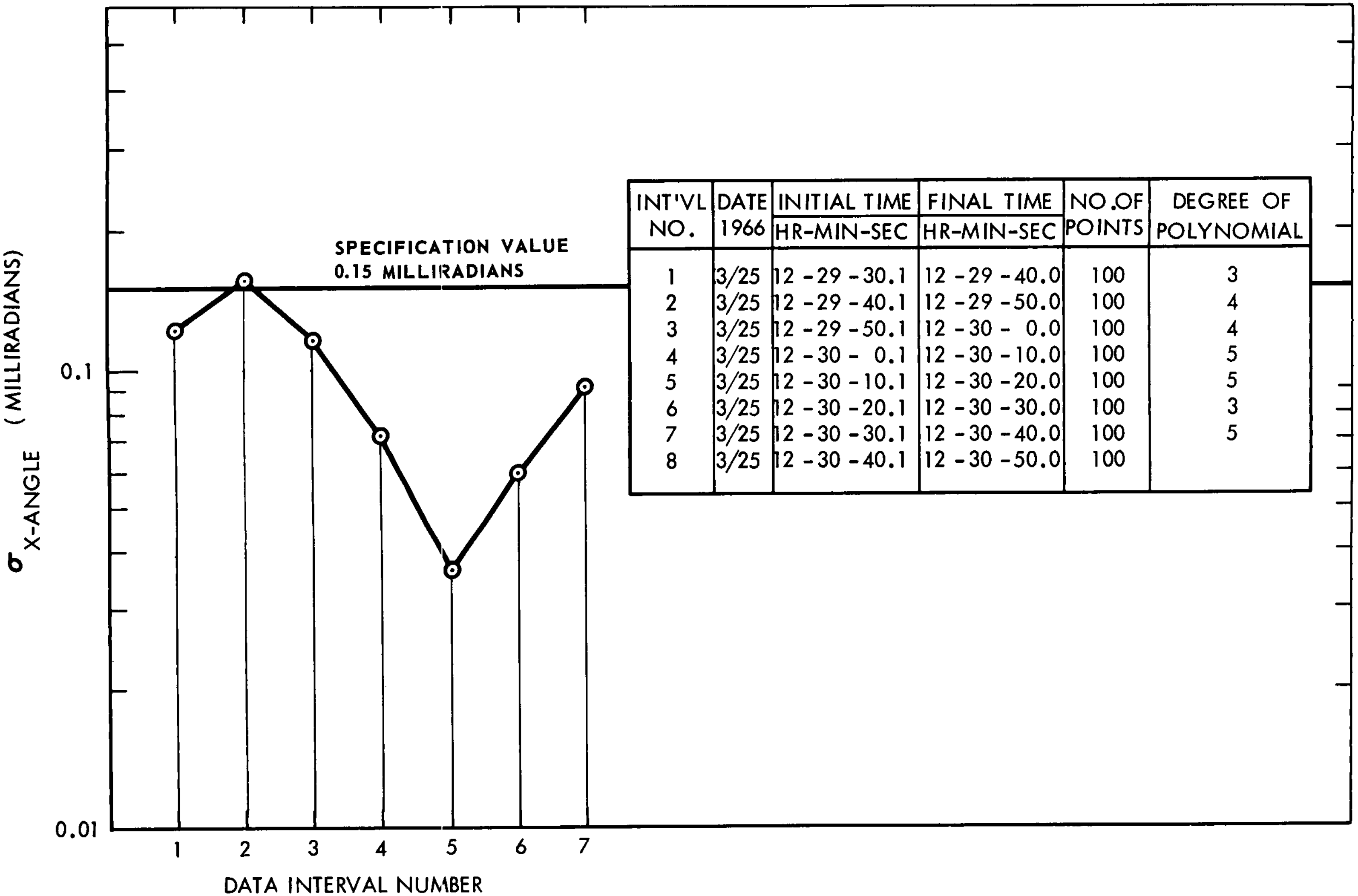
Figure 12



Carnarvon Flyby - March 25, 1966
Auto Correlation Function For
Range Rate Data (Interval 9)

Figure 13



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2	3/25	12 -29 -40.1	12 -29 -50.0	100	4
3	3/25	12 -29 -50.1	12 -30 - 0.0	100	4
4	3/25	12 -30 - 0.1	12 -30 -10.0	100	5
5	3/25	12 -30 -10.1	12 -30 -20.0	100	5
6	3/25	12 -30 -20.1	12 -30 -30.0	100	3
7	3/25	12 -30 -30.1	12 -30 -40.0	100	5
8	3/25	12 -30 -40.1	12 -30 -50.0	100	

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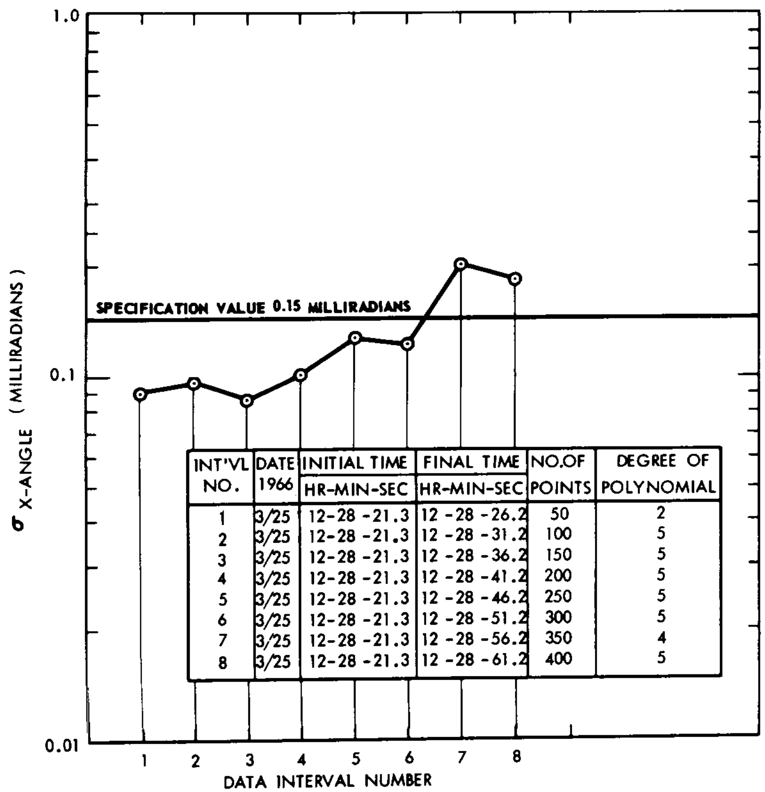
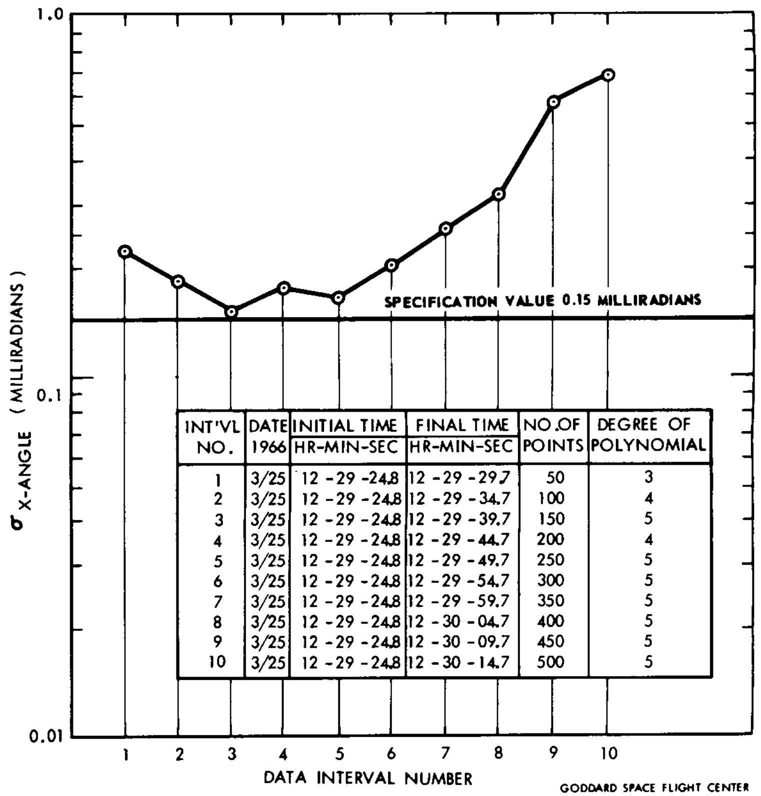
Carnarvon Flyby - March 25, 1966 X - Angle Data

Figure 14



INT'VL NO.	DATE 1966	INITIAL TIME HR-MIN-SEC	FINAL TIME HR-MIN-SEC	NO.OF POINTS	DEGREE OF POLYNOMIAL
1	3/25	12-28 -21.3	12 -28 -26.2	50	2
2	3/25	12-28 -21.3	12 -28 -31.2	100	5
3	3/25	12-28 -21.3	12 -28 -36.2	150	5
4	3/25	12-28 -21.3	12 -28 -41.2	200	5
5	3/25	12-28 -21.3	12 -28 -46.2	250	5
6	3/25	12-28 -21.3	12 -28 -51.2	300	5
7	3/25	12-28 -21.3	12 -28 -56.2	350	4
8	3/25	12-28 -21.3	12 -28 -61.2	400	5



INT'VL NO.	DATE 1966	INITIAL TIME HR-MIN-SEC	FINAL TIME HR-MIN-SEC	NO.OF POINTS	DEGREE OF POLYNOMIAL
1	3/25	12 -29 -24.8	12 -29 -29.7	50	3
2	3/25	12 -29 -24.8	12 -29 -34.7	100	4
3	3/25	12 -29 -24.8	12 -29 -39.7	150	5
4	3/25	12 -29 -24.8	12 -29 -44.7	200	4
5	3/25	12 -29 -24.8	12 -29 -49.7	250	5
6	3/25	12 -29 -24.8	12 -29 -54.7	300	5
7	3/25	12 -29 -24.8	12 -29 -59.7	350	5
8	3/25	12 -29 -24.8	12 -30 -04.7	400	5
9	3/25	12 -29 -24.8	12 -30 -09.7	450	5
10	3/25	12 -29 -24.8	12 -30 -14.7	500	5

GODDARD SPACE FLIGHT CENTER
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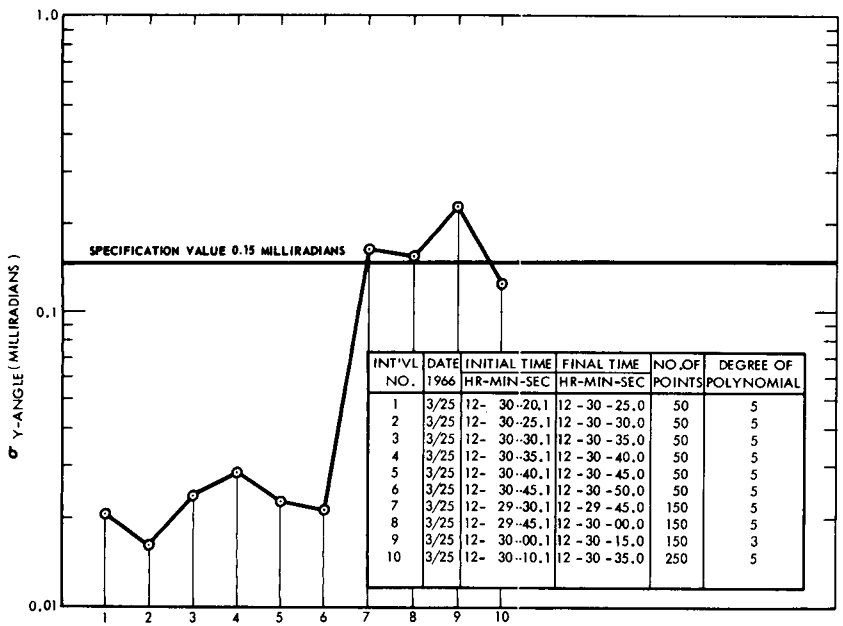
Carnarvon Flyby - March 25, 1966 X - Angle Data

(a)

(b)

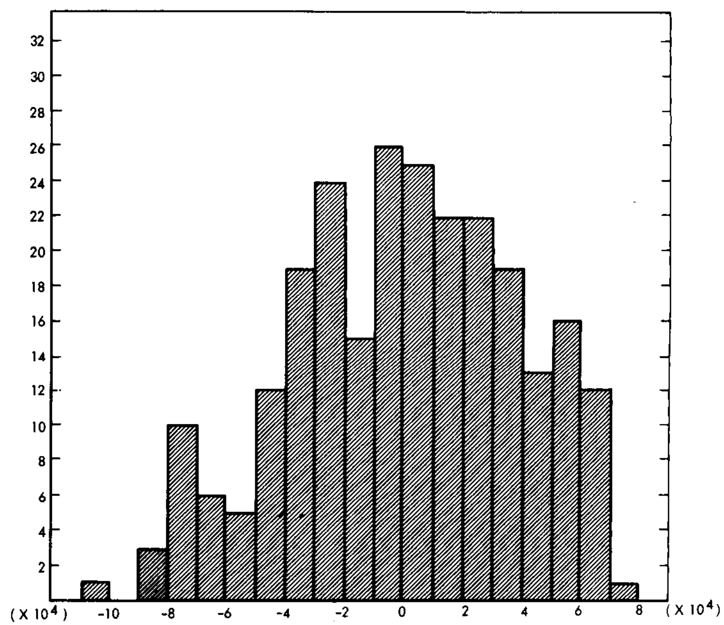
Figure 15



INT'VL NO.	DATE 1966	INITIAL TIME HR-MIN-SEC	FINAL TIME HR-MIN-SEC	NO. OF POINTS	DEGREE OF POLYNOMIAL
1	3/25	12- 30-20.1	12-30-25.0	50	5
2	3/25	12- 30-25.1	12-30-30.0	50	5
3	3/25	12- 30-30.1	12-30-35.0	50	5
4	3/25	12- 30-35.1	12-30-40.0	50	5
5	3/25	12- 30-40.1	12-30-45.0	50	5
6	3/25	12- 30-45.1	12-30-50.0	50	5
7	3/25	12- 29-30.1	12-29-45.0	150	5
8	3/25	12- 29-45.1	12-30-00.0	150	5
9	3/25	12- 30-00.1	12-30-15.0	150	3
10	3/25	12- 30-10.1	12-30-35.0	250	5

Carnarvon Flyby - March 25, 1966
Y - Angle Data

(a)



Carnarvon Flyby - March 25, 1966
Frequency Histogram
Y - Angle Data (Interval 10)

GODDARD SPACE FLIGHT CENTER
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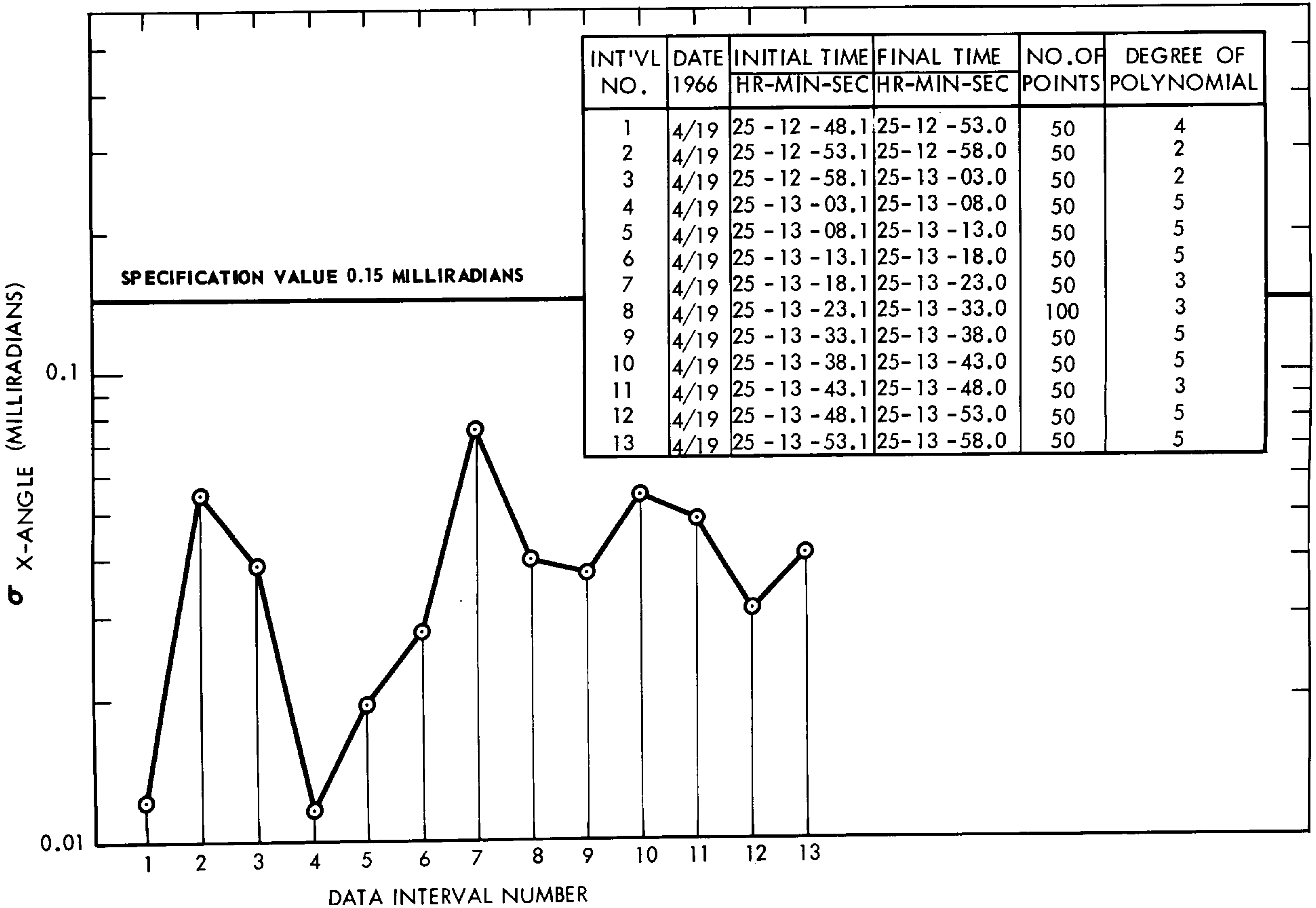
(b)

Figure 16



INT'VL NO.	DATE 1966	INITIAL TIME HR-MIN-SEC	FINAL TIME HR-MIN-SEC	NO. OF POINTS	DEGREE OF POLYNOMIAL
1	4/19	25 - 12 - 48.1	25 - 12 - 53.0	50	4
2	4/19	25 - 12 - 53.1	25 - 12 - 58.0	50	2
3	4/19	25 - 12 - 58.1	25 - 13 - 03.0	50	2
4	4/19	25 - 13 - 03.1	25 - 13 - 08.0	50	5
5	4/19	25 - 13 - 08.1	25 - 13 - 13.0	50	5
6	4/19	25 - 13 - 13.1	25 - 13 - 18.0	50	5
7	4/19	25 - 13 - 18.1	25 - 13 - 23.0	50	3
8	4/19	25 - 13 - 23.1	25 - 13 - 33.0	100	3
9	4/19	25 - 13 - 33.1	25 - 13 - 38.0	50	5
10	4/19	25 - 13 - 38.1	25 - 13 - 43.0	50	5
11	4/19	25 - 13 - 43.1	25 - 13 - 48.0	50	3
12	4/19	25 - 13 - 48.1	25 - 13 - 53.0	50	5
13	4/19	25 - 13 - 53.1	25 - 13 - 58.0	50	5

GODDARD SPACE FLIGHT CENTER
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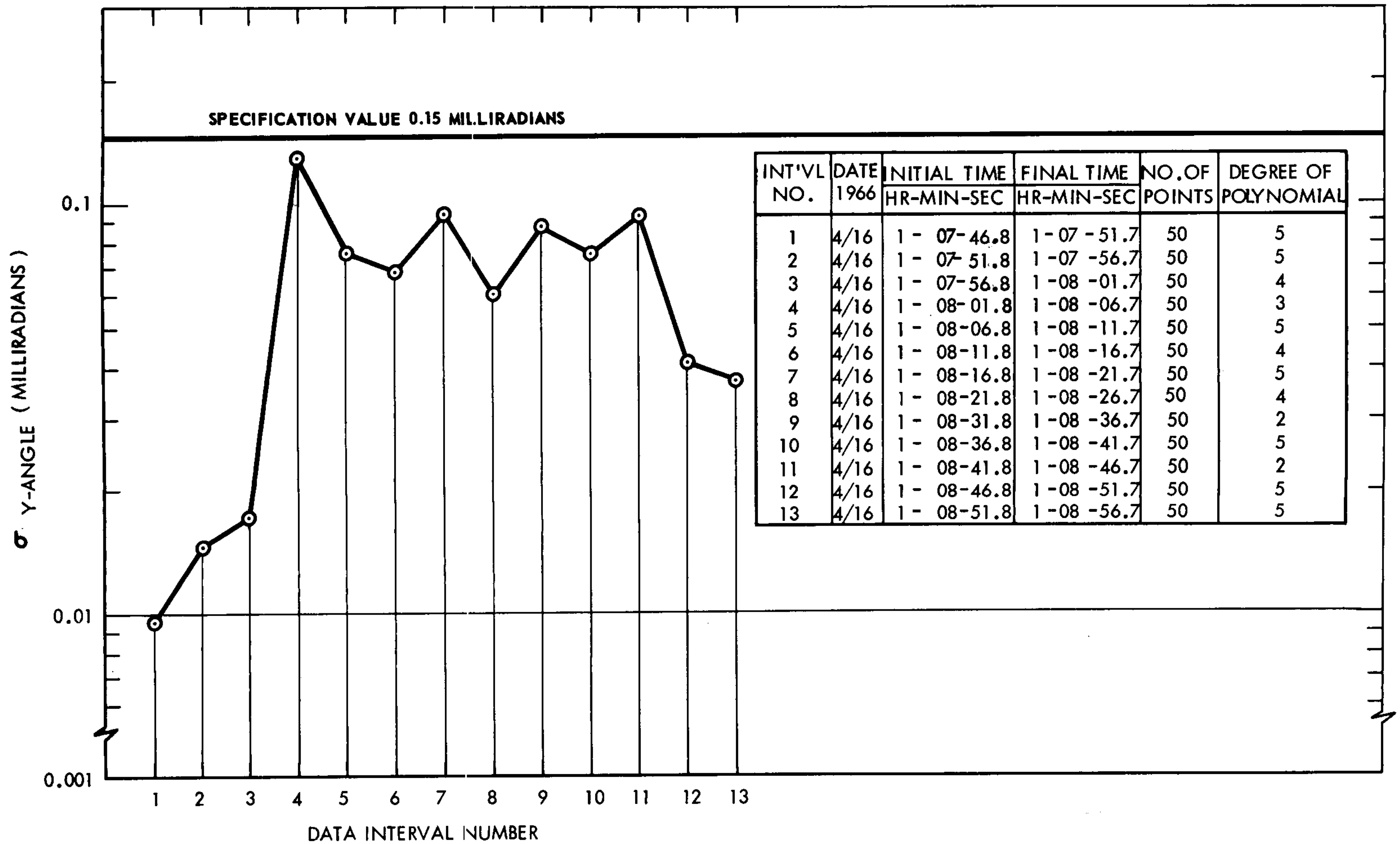
Merritt Island Flyby - April 19, 1966 X - Angle Data

Figure 17



INT'VL NO.	DATE 1966	INITIAL TIME HR-MIN-SEC	FINAL TIME HR-MIN-SEC	NO. OF POINTS	DEGREE OF POLYNOMIAL
1	4/16	1 - 07-46.8	1-07-51.7	50	5
2	4/16	1 - 07-51.8	1-07-56.7	50	5
3	4/16	1 - 07-56.8	1-08-01.7	50	4
4	4/16	1 - 08-01.8	1-08-06.7	50	3
5	4/16	1 - 08-06.8	1-08-11.7	50	5
6	4/16	1 - 08-11.8	1-08-16.7	50	4
7	4/16	1 - 08-16.8	1-08-21.7	50	5
8	4/16	1 - 08-21.8	1-08-26.7	50	4
9	4/16	1 - 08-31.8	1-08-36.7	50	2
10	4/16	1 - 08-36.8	1-08-41.7	50	5
11	4/16	1 - 08-41.8	1-08-46.7	50	2
12	4/16	1 - 08-46.8	1-08-51.7	50	5
13	4/16	1 - 08-51.8	1-08-56.7	50	5

GODDARD SPACE FLIGHT CENTER
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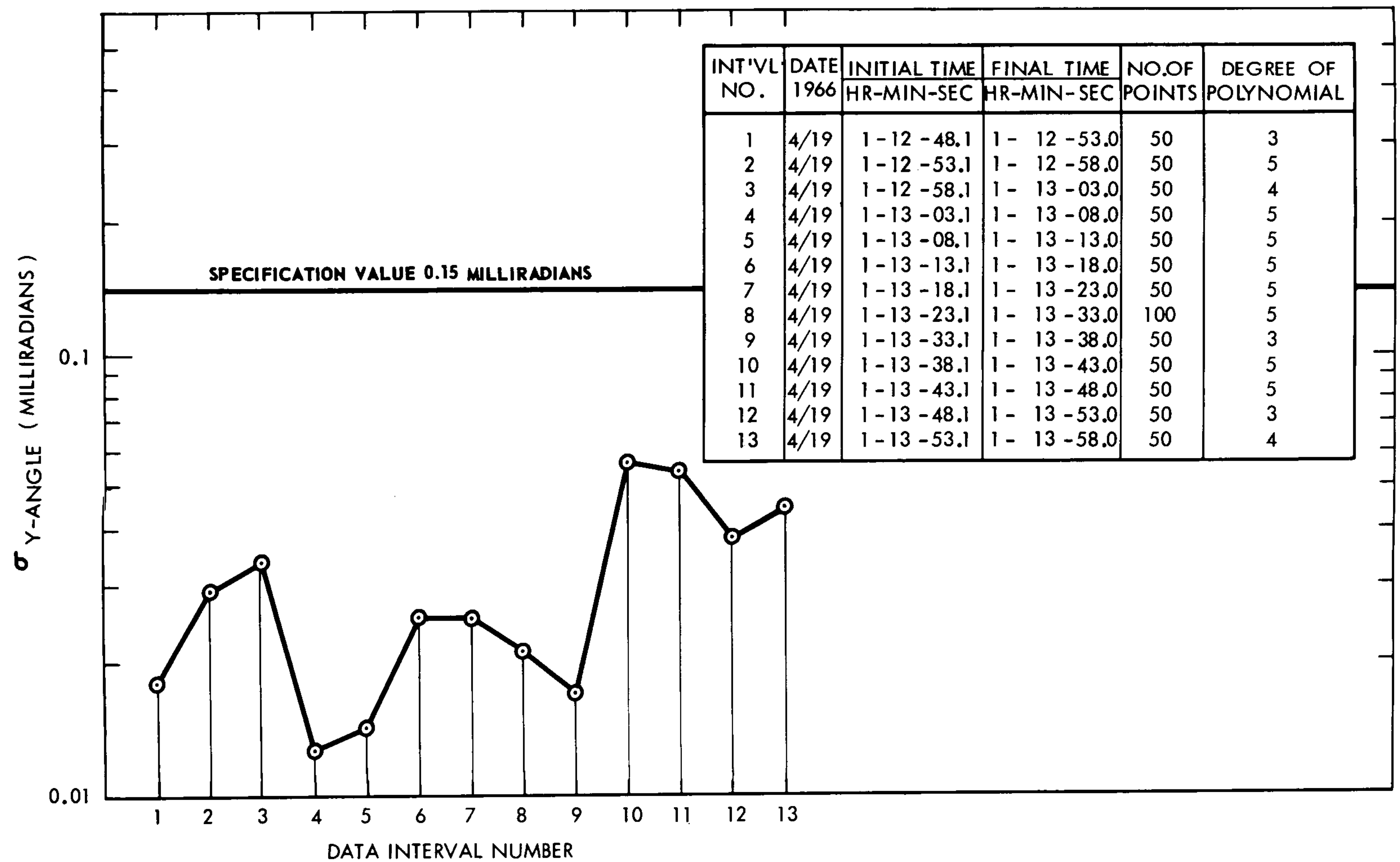
Merrit Island Flyby - April 16, 1966 Y - Angle Data

Figure 18



INT'VL NO.	DATE 1966	INITIAL TIME HR-MIN-SEC	FINAL TIME HR-MIN-SEC	NO.OF POINTS	DEGREE OF POLYNOMIAL
1	4/19	1-12-48.1	1-12-53.0	50	3
2	4/19	1-12-53.1	1-12-58.0	50	5
3	4/19	1-12-58.1	1-13-03.0	50	4
4	4/19	1-13-03.1	1-13-08.0	50	5
5	4/19	1-13-08.1	1-13-13.0	50	5
6	4/19	1-13-13.1	1-13-18.0	50	5
7	4/19	1-13-18.1	1-13-23.0	50	5
8	4/19	1-13-23.1	1-13-33.0	100	5
9	4/19	1-13-33.1	1-13-38.0	50	3
10	4/19	1-13-38.1	1-13-43.0	50	5
11	4/19	1-13-43.1	1-13-48.0	50	5
12	4/19	1-13-48.1	1-13-53.0	50	3
13	4/19	1-13-53.1	1-13-58.0	50	4

GODDARD SPACE FLIGHT CENTER
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Merritt Island Flyby - April 19, 1966 Y - Angle Data

Figure 19